KINGS RIVER WATER QUALITY COALITION

An Assessment of Sediment and Erosion Risks within the Kings River Water Quality Coalition as Required by the General Order of Waste Discharge for the Tulare Lake Basin, R5-2013-0120

Sediment and Erosion Assessment Report

November 20, 2014

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TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

The Sediment and Erosion Assessment Report (SEAR) is a required report to be prepared by the Kings River Water Quality Coalition (KRWQC) under the General Order of Waste Discharge for Growers within the Tulare Lake Basin Area that are Members of a Third Party Group (R5-2013-0120).

The KRWQC has utilized the construction permit data available from the State Water Resources Control Board and categorized the data into risk categories using ArcGIS software. Risk categories were set at levels of 0-5 tons/year, 5-10 tons/year, 10-15 tons/year, 15-20 tons/year, and 20 or more tons/year. Each level was assigned a text description of the risk (none, low, medium, high, and extreme) based on its tons/year rating, and color coded on a base map.

Surface water bodies that are known to be active were then placed upon the map, and outlined with a 500 meter (1,640 ft.) boundary. This boundary was determined to be the largest practical buffer for surface runoff from agricultural parcels to surface water bodies. The KRWQC then overlaid member parcels (as of the completion of open enrollment) to determine who was subject to the Sediment Control Plan requirements.

A Quality Assurance/Quality Control (QA/QC) analysis was then performed on the resulting data so that parcels that only touched the boundaries, but posed no real risk, was removed from the final listing. A dual classification system was devised for those parcels that are located in such a way that another parcel is between the parcel in question and the waterway so that these “exterior” parcels would be listed as “Self-Assessment” rather than “Mandatory”. Enrolled parcels that showed no irrigated agriculture on a 2012 Aerial photograph were dropped. The KRWQC analysis identified 289 affected parcels (189 Mandatory, 100 Self-Assessment).

The final analysis of the available data shows that the overall risk of sediment movement into surface waters within the KRWQC is very low and those areas that are affected are limited to the irrigated lands in the foothill areas in the eastern portions of the valley floor.

INTRODUCTION

The General Order of Waste Discharge for the Tulare Lake Basin (R5-2013-0120) requires a number of reports to be prepared by the approved "third-parties," each addressing a specific aspect of the regulations. The Kings River Water Quality Coalition (KRWQC), as the approved third-party for the Kings River and Tulare Lake Basins, is required to prepare a Sediment and Erosion Assessment Report (SEAR) that identifies those parcels that pose a risk of sediment discharge into the surface waters within the KRWQC service area. Owners of irrigated parcels identified as being at risk of sediment discharge will be required to prepare and implement Sediment and Erosion Control Plans that mitigate the erosion risk to such waters. These owners will document existing practices, and potentially implement additional practices should they be necessary.

This Assessment report will identify parcels that are at risk according to the analysis of the KRWQC service area using specific criteria; additional threats to surface water will need to evaluated on a site by site basis.

HYDROLOGIC BACKGROUND

The Kings River is located in the Tulare Lake Hydrologic Basin in the southern portion of the San Joaquin Valley. It is comprised of the Kings River North and the Kings River South (splitting at the Army Weir/Island Weir complex north of Lemoore). The river is also operationally divided into the "upper river" (Pine Flat to Hwy 99) and the "lower river" (below Hwy 99). The upper river typically has water in it year-round (except in very dry years), while the lower river is active only during the summer months or during flood operations. The KRWQC comprises the Kings River Basin, the Tulare Lakebed, and the Kings River Watershed above the Valley floor.

The Kings River watershed area includes about 1,700 square miles above Piedra; 1,545 of which lies above Pine Flat Dam. It lies along the westward face of the highest portion of the Sierra Nevada. Elevations in the watershed area range from a maximum of about 14,000 feet at the headwaters to about 400 feet at the edge of the Valley floor. This watershed area is among the most rugged of the entire Sierra Nevada and is characterized by sharp peaks and ridges, precipitous canyons, and granite domes. Kings River headwaters are comprised of many small glacial lakes at elevations of 12,000 feet or more, near the crest of the Sierra Nevada. Nearly all of the tributaries flow in deep granite canyons and the main canyon below the junction of the Middle and South Forks is more than 5,000 feet deep. The soil cover, except for granite outcroppings and precipitous canyons, ranges from moderate in the lower area to non-existent above 10,000 feet elevation. No irrigated agriculture takes place in the watershed above Pine Flat Dam.

Just below Pine Flat Lake, from the mouth of the canyon below Piedra, the Kings River flows southwesterly to near Centerville and on to Centerville Bottoms. Beginning near Kingsburg, the river is provided with continuous flood control levees through the lower reaches of the river.

Mill Creek and Hughes Creek are uncontrolled drainages that join the Kings River just below Pine Flat Dam. Mill Creek, being the larger of the two drainages, has an Army Corps of Engineers gauging station to monitor its flow. Hughes Creek, being much smaller, does not have a gauging station, and its flows are estimated by the change in river flows measured at the Piedra gauging station (Piedra flow rate minus the sum of Pine Flat releases and Mill Creek flow rates yields estimated Hughes Creek flow).

Additional drainages within the Kings River Water Quality Coalition (KRWQC) service area include Tivy Creek, Wahtoke Creek, and Traver Creek. These are ephemeral streams that originate in the foothills and drain toward the Kings River channel. Traver Creek is intercepted by a major canal that channels Kings River water south to the Tulare Lake bed.

Irrigated field crops are confined to the lower foothills and valley floor region of the KRWQC service area. Orchard plantings dominate the foothill regions of the KRWQC service area due to favorable climatic conditions present during the winter months. The developed lands were originally open grasslands and bare rock outcroppings, but now support considerable irrigated agricultural activity. Field and row crops dominate the lower portions of the valley floor, with interspersed permanent crops such as vines, almonds, and pistachios.

Erosion is a natural process that existed long before the introduction of irrigated agriculture to the region. It is the transport of surface materials dislodged by rainfall or other disturbances and that material's eventual movement into channels where flowing water is present. Erosive processes are gravity driven, and are impeded or enhanced by soil surface conditions (presence/absence of vegetative cover, slope, and soil texture). Erosive forces can be applied either by water or wind. Water is the key lubricant for the mass movement of soil particles in response to the gravitational gradient once they are dislodged (land slide or slump). Erosion is shown in the transport/deposition of sediments within a streambed due to changes in stream velocity or in the measured increase in turbidity or other physical parameter measurements.

Rainfall intensity has considerable influence on the type of erosion that can occur. Intensities rarely reach levels of large-scale sheet flow events; rill erosion is more common as surface water flows gather into larger, faster flowing rivulets.

Mill Creek in particular is subject to considerable erosion during the first few months of the rainfall season. The soils are fine textured, very dry (initially), have very little vegetative cover (having been disturbed by grazing or burrowing animals), and has significant slopes. Its large watershed and rapid rises and falls in flow rates can create a situation where considerable sediment is washed into the Kings River downstream of Pine Flat Dam.

The Kings River from Pine Flat to Hwy 180 is relatively steep and the bottom of the streambed is composed of cobbles or other rocks (the biologists refer to the river bottom as "armored"). Loose sediment that fish or insects require for egg laying is in short supply, so the deposits that become available due to surface erosion can actually be beneficial to overall fishery health, providing that the sizing of the sediment particles is correct.

Soil sediments are of concern within the riparian habitat due to its ability to capture hydrophobic compounds. As most of the active ingredients within agricultural pest control materials are complex hydrocarbons and naturally hydrophobic by chemical nature, these materials are known to adsorb onto soil particles once they are freed from the emulsifying chemistries used to make the materials marginally water soluble. It is here where they pose a risk to those benthic organisms that occupy the stream bottom sediments.

Erosion risk from disturbed surface soil profiles that are associated with irrigated agriculture is the primary focus of this evaluation report. All lands within the KRWQC boundaries will be analyzed for erosion potential and erosion events from non-irrigated lands (pastures and other lands outside of the scope of the General Order) will need to be documented, but little can be done to prevent such movements.

EROSION AND AGRICULTURE

The soils within the KRWQC are formed from the alluvium of previous erosive events, and the natural movement of these soils continues to this day. The construction of dams (particularly Pine Flat) has reduced the major erosive events that would lead to large scale deposition of materials on the valley floor by controlling the flow rates within the Kings River system (through the controlled release of water from the dam, and the presence of the impounded reservoir, which reduces stream velocity and its ability to transport sediments). The foothills on the west face of the Sierra Nevada are previously deposited sediments that are being uplifted as the granitic batholith that comprises the Sierra Nevada slowly tilts upward. Erosion will continue until the potential energy of the soil particles reaches zero. Native vegetation (grasses, trees) act as stabilizing forces to hold soils on slopes that have temporarily stabilized, but the power of flowing water will eventually overcome this binding action and the sediments will continue their downward movement. The severity of erosion depends upon the intensity of the rainfall event, the slope of the land surface, the porosity (texture) of the soil in question, and the duration of the event.

Irrigated agricultural operations seek to introduce a controlled vegetation regime upon the land. To do so, the soil surface must be disturbed and made ready for the introduction of the desired plant materials. This includes the disruption of deeper soil layers that may inhibit water movement or root growth. Also, during the cultivation of the desired plants, additional actions are taken to suppress the regrowth of the displaced “native” species. Harvest or other cultural operations can create conditions that promote erosion (wheel tracks, soil compaction/loss of porosity) when performed during wet conditions. The growers in this region attempt to minimize this risk during the winter months due for safety reasons.

The Mediterranean climatic conditions within the KRWQC require that supplemental irrigation water be applied for crop production. The methods for applying this supplemental water have changed from the simple gravity flow from a ditch or pumped groundwater into furrows or narrow basins to highly sophisticated micro irrigation systems (drip, microsprayer, buried drip) that rely on either groundwater or surface water (sometimes both). The method of irrigation used is dependent upon the crop grown (its value determines the sophistication of the irrigation method) or the conditions (slope, water availability) upon which the crop is grown. Older irrigation methods (furrow, flood) have the tendency to create more erosion than the micro systems due to the volumes of water involved and the velocity of the water across the erodible surface. Micro systems apply the water at rates that rarely exceed the soil’s capacity to infiltrate the water into the rootzone. This leaves substantial areas of “dry” soil outside of the application area that readily absorbs rainfall.

Unlike the Midwest where climatic conditions are conducive to preserving organic matter within the soil profile, soils in the arid west do not have the soil biota necessary to construct and maintain macropores within the soil profile (large scale earthworm activity, higher percentages of organic matter) that would significantly increase soil infiltration rates. Organic matter content is practically non-existent within the local soils, as the lack of water and the high summer temperatures literally “cook” the matter out of the soil before it can accumulate. Fine textured soils here must rely on chemical modification of soil porosity (see below) or on the remaining root structures of previous vegetation to maintain the soil pore structures that support high infiltration rates.

Management practices for the preservation of surface soil have been applied with varying degrees of success throughout the more vulnerable areas of the KRWQC. Erosion of hillsides impacts a grower’s ability to access his land or can potentially damage his investments (crop, equipment, labor), so practices are developed and implemented to minimize such risks. Protection of existing soil structure on high slope portions of fields is paramount. Excessive infiltration can lead to the destabilization of the slope as the surface layers move independently of the underlying soil structure. High slope soils are not conducive to furrow irrigation, so micro irrigation practices have been adopted. Organic matter (straw or other), which reduces the forces of impact when rainfall hits soil particles, is impractical over large areas due to material availability and the potential to be hazardous to equipment and harvest crews (by leaving the underlying soil soft and unstable). In regions where cold air drainage occurs naturally, native or introduced vegetation is used to stabilize the soil profile.

Irrigated agriculture has also sought to control erosion through chemical alteration of the soil surface. Gypsum is a calcium rich mineral that causes soil particles to bind together into larger aggregates by displacing monovalent cations from the soil structure (primarily sodium) and replacing them with divalent calcium. The divalent calcium then binds two adjoining soil colloids together; changing how the colloids relate to one another (they are now aligned in random directions, rather than in flat plates, a process called flocculation). This allows more water and air to penetrate the soil structure, enhancing root health and promoting better soil structure.

Where lime (calcium carbonate) is present, acid forming fertilizers are used to dissolve the lime and free the calcium. Again, the soil structure is flocculated, and the carbonate is released as a gas (CO_2) and water. Both processes are slow and have limited periods of effectiveness due to the soil's native ability to buffer itself back into equilibrium.

EVALUATION OF EROSION POTENTIAL

The KRWQC has reviewed the proposed East San Joaquin Water Quality Coalition's (ESJWQC) Sediment and Erosion Control Report which was submitted to the Regional Water Quality Control Board in January 2014. We initially found no fault in the proposed methodology, in that it appeared to represent the most efficient means of identifying the relevant parcels that may require a Sediment and Erosion Control Plan.

As in the ESJWQC Report, we thought we would begin with the Universal Soil Loss Equation (USLE), and remove those factors that remain constant regardless of local conditions. The equation is stated as:

$$A = R \times K \times L \times S \times C \times P$$

where A = annual soil loss, R = rainfall erosivity (rainfall intensity), K = soil erodability (mg MJ^{-1} mm^{-1}) when the field is bare, L = length of slope, S = field slope, C = crop management factor, and P = conservation practice. The "C" term can be further defined for changes throughout the crop year and measured over multiple years. When dealing with a permanent cropping system, the "C" and "P" terms can be assumed to remain constant and thus dropped from the final calculations.

It was later discovered that the available data needed to make the necessary calculations required a considerable amount of preprocessing in order to be used in a GIS analysis. The ESJWQC consultant indicated that their analysis was flawed, and when corrected, identified their entire coalition service area as highly vulnerable to erosion. At the Regional Board's suggestion, they switched to using the State Water Resources Control Board's Construction General Permit guidelines, which rely on EPA's definition of erosivity for "disturbed" soil. Agricultural soils in those areas that would be intuitively classified as high risk are typically not disturbed beyond the initial development activities, and the longer the soil remains undisturbed after the initial development, the lower the risk becomes. Agricultural soils are also not disturbed to the extent that full on construction activities would, so the basic risks would be less. The ESJWQC is currently determining what thresholds they wish to use for setting erosion risk for irrigated farmland.

The new method relies on the RUSLE-2 (Revised Universal Soil Loss Equation, version 2) which is the approved equation for Natural Resource Conservation Service (NRCS). This equation is as follows:

$$a_i = r_i \times k_i \times l_i \times S \times c_i \times p_i$$

where a_i = average annual soil loss, r_i = erosivity factor, k_i = soil erodability factor, l_i = soil length factor, S = slope steepness factor, c_i = cover-management factor, and p_i = supporting practices factor, all on the i^{th} day. For RUSLE-2, these factors are considered on a *daily* basis, rather than a yearly basis, which is why the terms are in lower case. Slope remains the only constant value throughout the year. RUSLE-2 is structurally very similar to that of RUSLE, but the internal mathematics considers additional factors such as deposition (both local (distances in millimeters) and remote (distances in meters). The addition of this condition, plus the daily measurement of the annual soil loss (a_i) increases the power of RUSLE-2 over RUSLE or USLE.

As in the original ESJWQC analysis, certain factors in the USLE or RUSLE-2 equations can be set as constants and thus removed. This is discussed in the next section.

The following datasets were downloaded for analysis:

1. State Water Resources Control Board: State Water Board data and guidelines for construction general permits (ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk)
2. gSSURGO: Gridded Soil Survey Geographic (gSSURGO) Database for California. United States Department of Agriculture, Natural Resources Conservation Service. (http://datagateway.nrcs.usda.gov). This is the FY2014 official release.

DISCUSSION

The State Board data provided the following terms for the USLE/RUSLE-2 equation: R, K, L, and S (used as r_i, k_i, l_i, and S). The gSSURGO data is in 10-square meter pixels, which were converted to an appropriate raster for ArcGIS analysis. The remaining terms in the equation (c_i and p_i) are assumed not to change within a permanent planting.

It was determined to set the r_i factor at 100%, essentially looking at the erosive potential for a particular element for the entire year. Land in permanent plantings is only disturbed a couple of times per year (if that), and generally only during the dry season. The greatest period of surface soil disturbance is during initial planting, installation of any irrigation systems, and during harvest. Other equipment operations within such plantings (sprayers) use floatation tires to minimize soil compaction. Weed control (spot spraying of isolated weeds or row middle spraying) or irrigation system inspections typically use a quad or "rhino" type vehicle which has a minimal soil surface impact. Pesticide spraying uses heavier tractors and air-blast sprayers.

The GIS analysis produced predicted values of annual soil loss (A or a_i, depending on which equation is being used), which were then categorized as being within the following range definitions:

0-5 tons of soil loss per year
5-10 tons of soil loss per year
10-15 tons of soil loss per year
15-20 tons of soil loss per year
20 or more tons of soil loss per year

The NRCS standard indicates that predicted losses less than 5 tons/year pose no erosion risk. The 5 to 10 tons/year would be low risk, 10-15 tons/year would be moderate risk, 15-20 would be high risk, and values greater than 20 would be extreme risk. These zones were color coded on the regional map that had been clipped to match the KRWQC boundaries.

The base layer used was a standard 3-D elevation map for the Coalition service area. The soil loss prediction layer was added on top of this map, and each category color coded.

The next step was to overlay the active hydrologic features onto the map and set a risk boundary around each waterway. A 500-meter (1,640 ft.) boundary was placed around the selected waterways. Any parcels outside of this boundary were considered to be no risk to surface water, regardless of the risk category that they resided within.

Once these factors were added to the base map, the member enrolled parcels layer was added. The GIS software was programed to highlight/count those parcels that intersected the 500-meter boundary area and resided within a risk category of 5 tons/year or higher. The KRWQC identified 289 member parcels that met these criteria. This does not represent all the possible parcels that exist within the defined zones, only those who have enrolled within the KRWQC.

The next step was a QA/QC evaluation of the affected parcels. Knowing that some growers have enrolled parcels that are not actively farmed, a layer showing 2012 aerial photography of the region was added to the analysis. Each of the regions that showed vulnerable parcels was examined closely to determine if they were actually a risk to surface water, or if they were included because their defined parcel boundary just happened to touch the 500-meter zone. Two compliance categories were set up within the data, "Mandatory" Sediment and Erosion Control Plan for parcels that obviously fell within the 500-meter boundary, and a “Self-Assessment” requirement. If the parcel just touched the 500-meter boundary, it was classified as a “Self-Assessment” parcel, as well as any parcels that had parcels between the target parcel and the water body. If the aerial photography failed to show irrigated agriculture activity, then the parcel was dropped.

Consideration was also made for parcels that were obviously downhill from a water body, where surface flow would move away from the target water body. Buffer zones were not drawn for water bodies with known barriers to surface runoff (levees). For this analysis, the Friant-Kern Canal was excluded.

The initial analysis (500-meter boundary and 5 tons/year) yielded 289 parcels that would fall under the requirements; further QA/QC reduced the number to 189 that require a sediment and erosion plan, and 100 that may require a self-assessment.

The majority of the parcels are located along the Kings River below Pine Flat Dam; the others are located on the Tivy and Wahtoke Creek watersheds with isolated parcels along the San Joaquin River and some other minor creek beds. Very few parcels are located in the >20 tons/year category, which is mostly the Kings River watershed in the Sierra Nevada.

Each of the mapping layers is shown in the attached figures.

KRWQC ACTIONS

Once this SEAR is approved by the Executive Officer, notifications will be prepared for each of the affected landowners regarding the requirements. The landowners will be referred to the Fresno NRCS office for obtaining the necessary Sediment Control Plan(s). Compliance follow up will take place with the Farm Evaluations submitted to the KRWQC.

The KRWQC will update the member parcel map and check for Sediment Control Plan requirements when new parcels are enrolled and with each billing cycle. Those parcels found to require a control plan will have the owners/operators notified within 30 days of acceptance.

APPENDIX

Figure 1: R Value Map

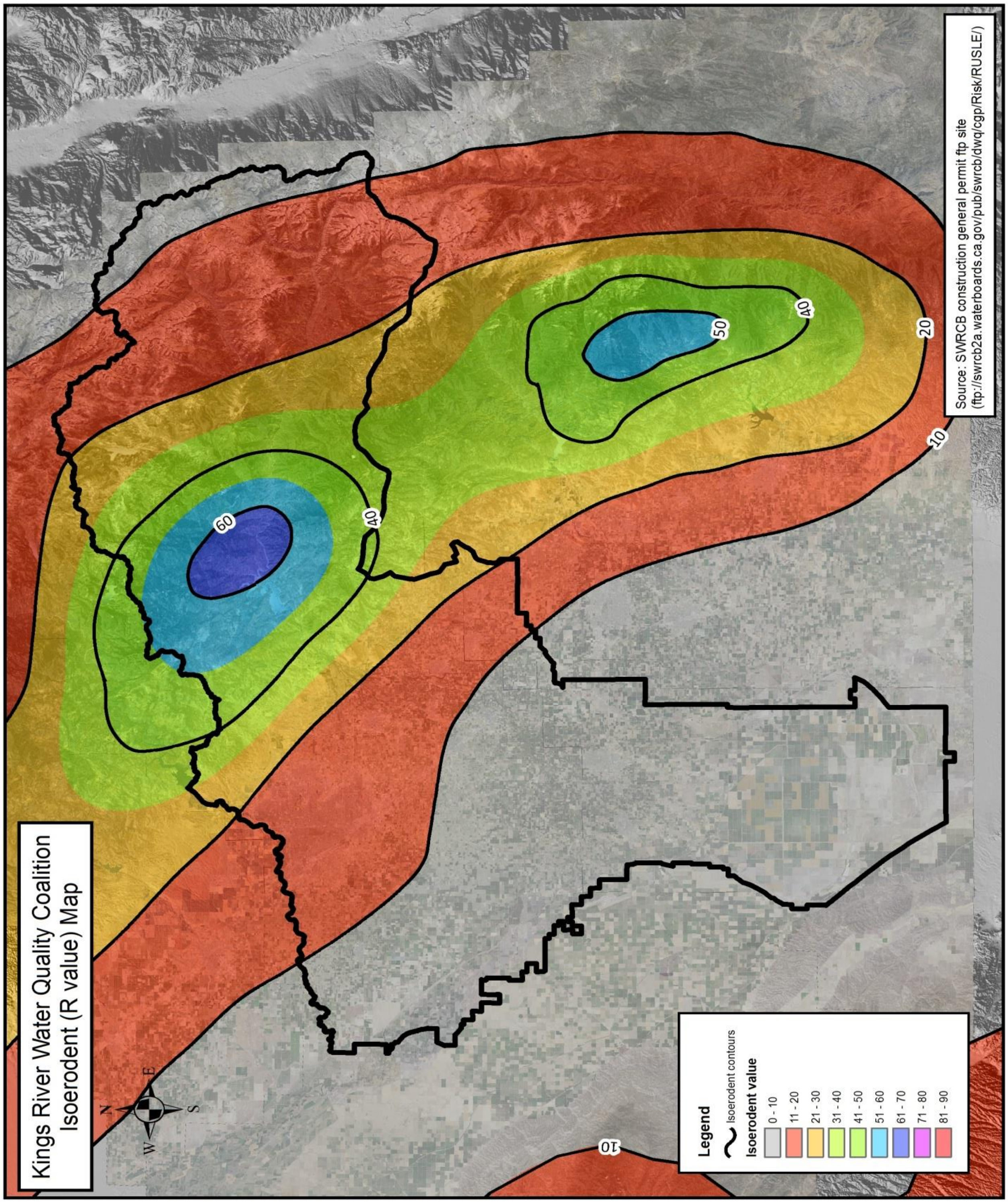

Figure 2: K Factor Map

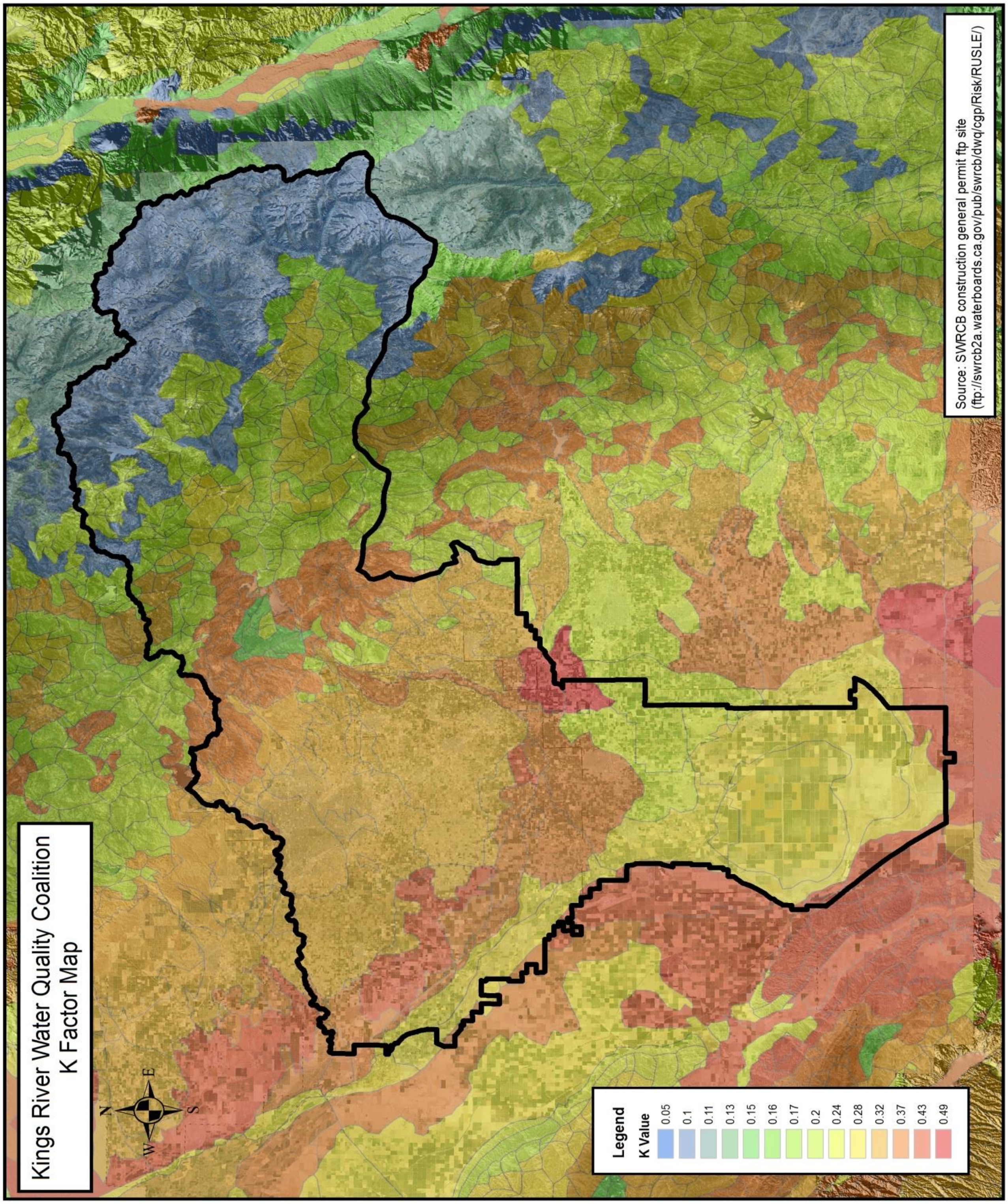

Figure 3: LS Factor Map

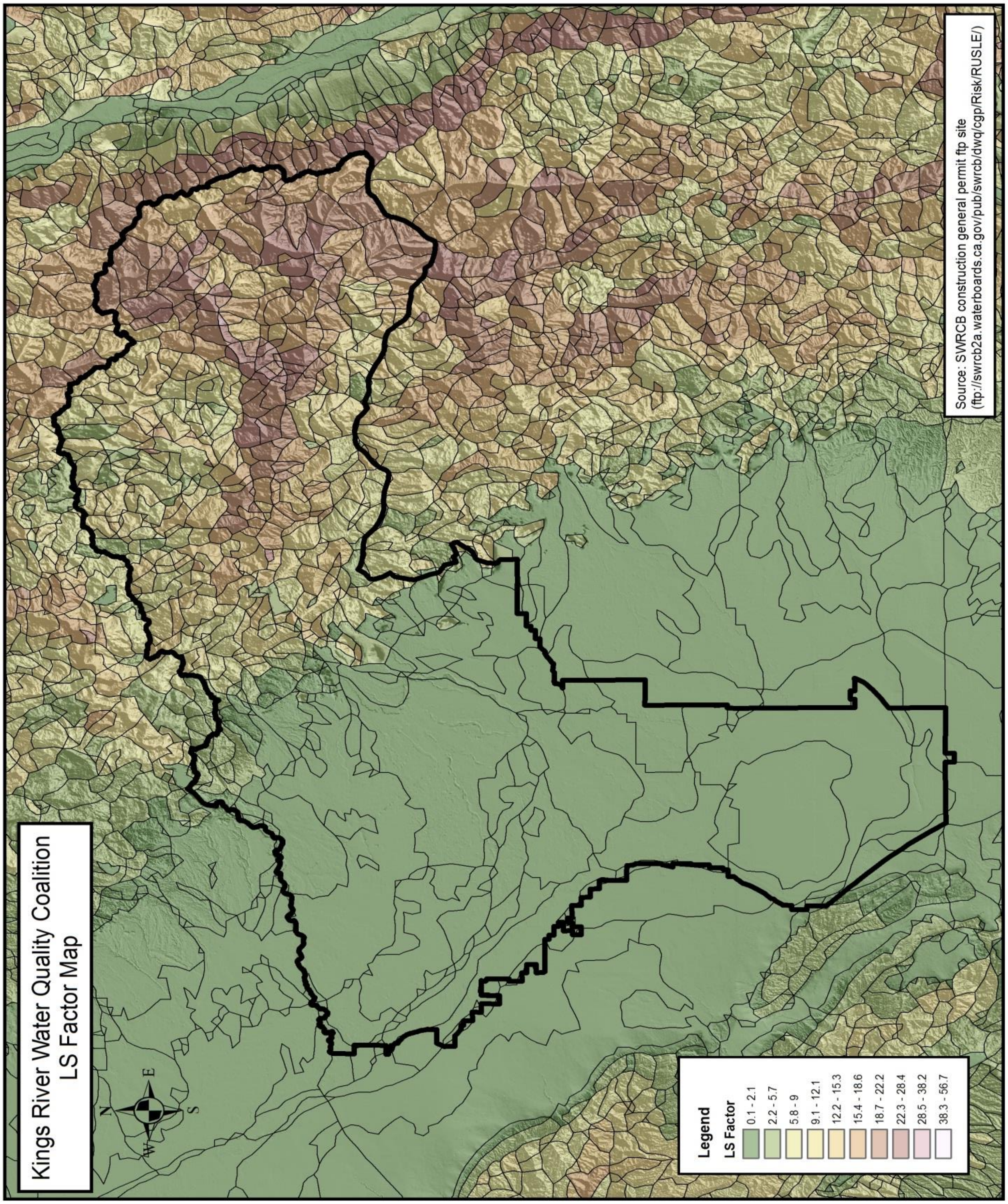

Figure 4: Multiplied Factors Map

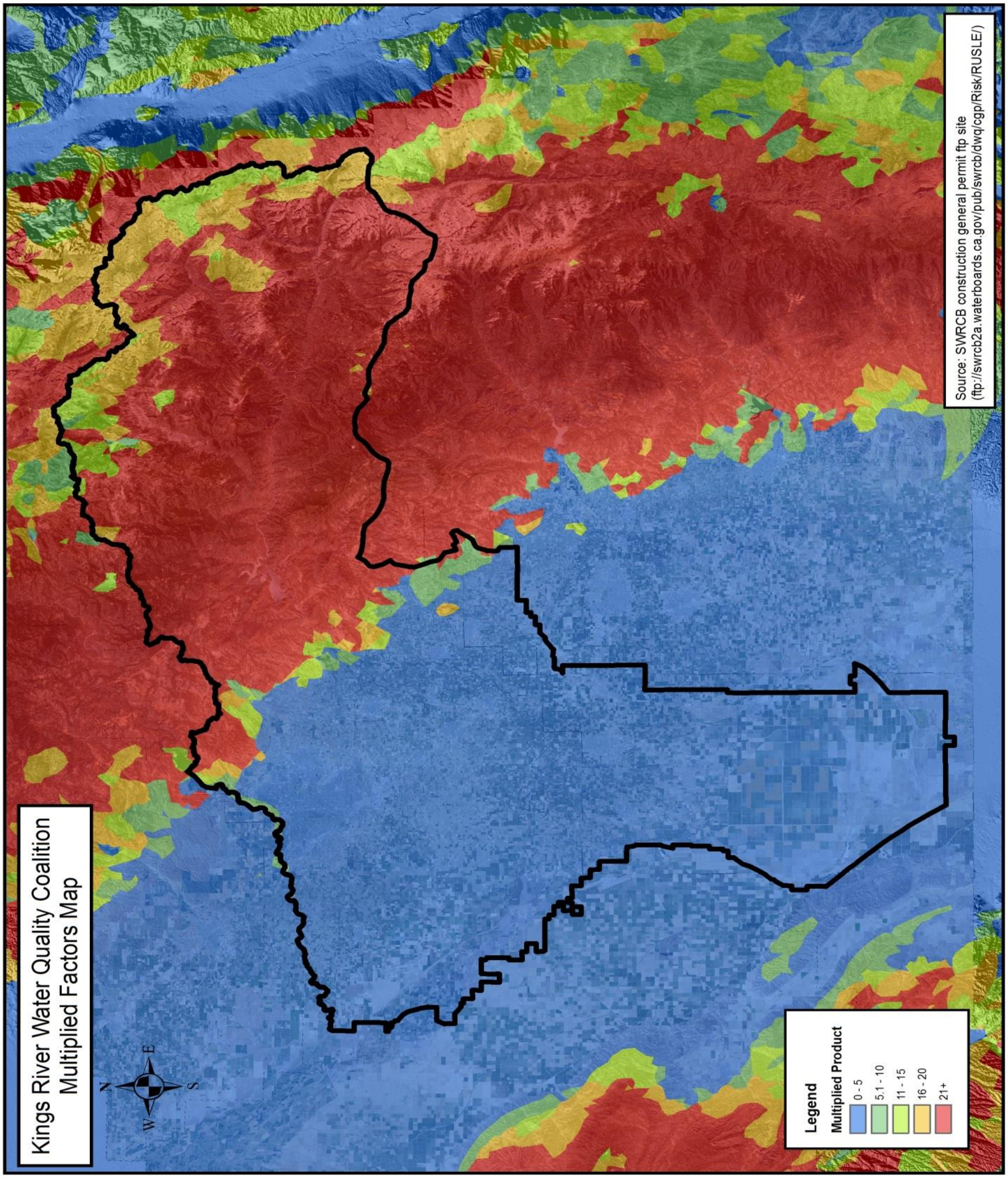

Figure 5: Hydrologic Map

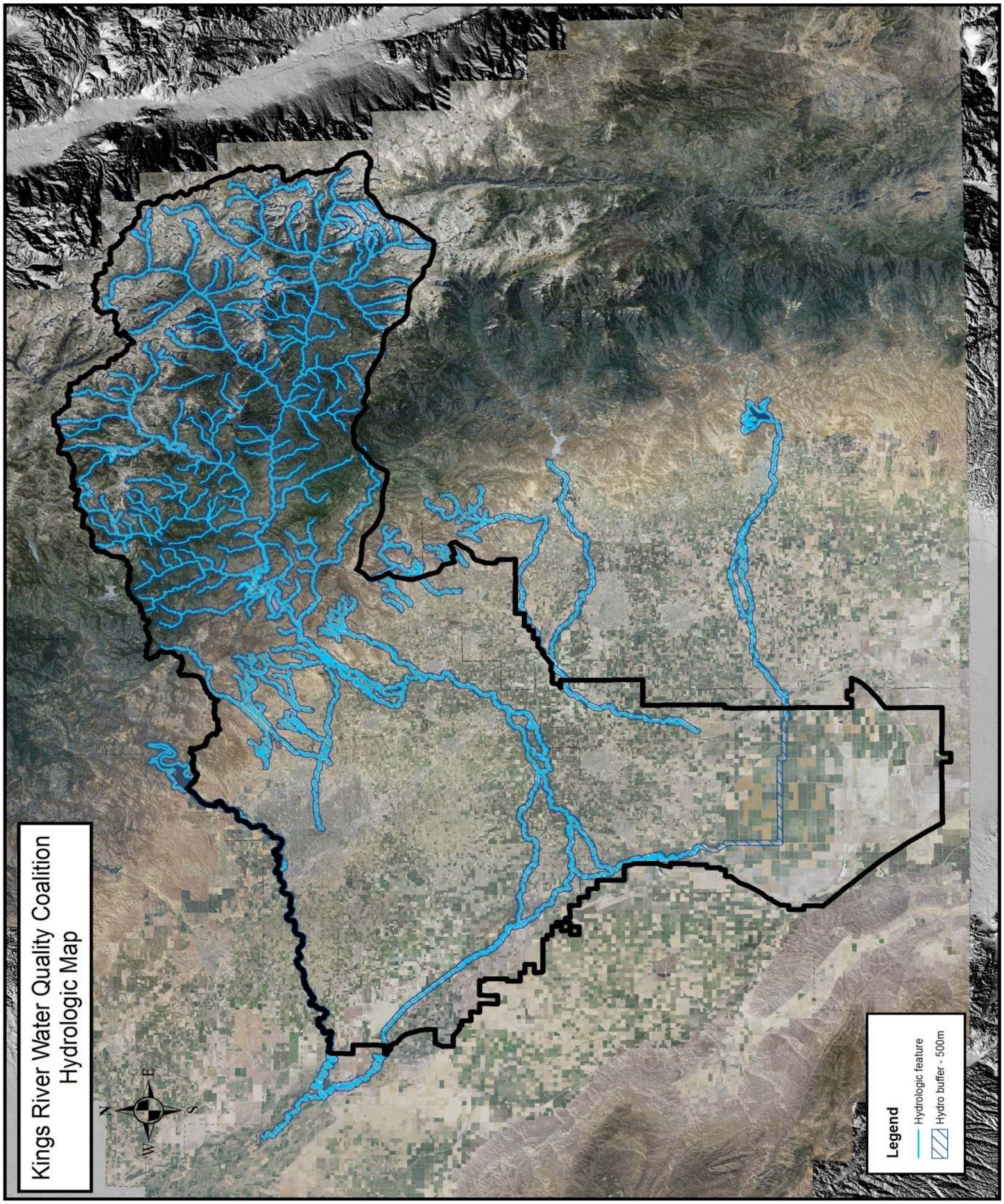

Figure 6: KRWQC Member Parcel Map (September 2014)

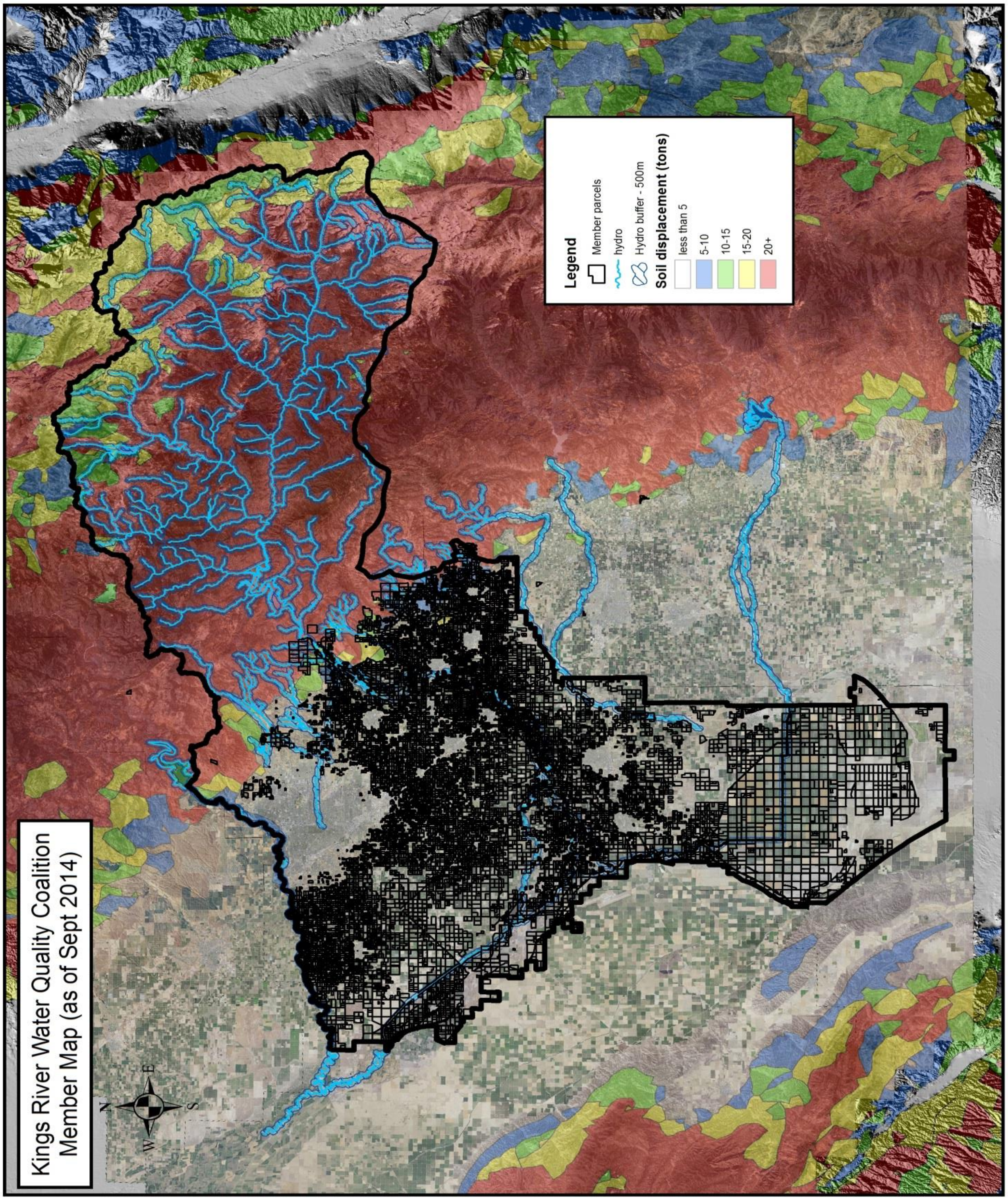

Figure 7: Sediment and Erosion Assessment Map